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Nanophotonic Devices; Spontaneous Emission Faster than Stimulated Emission

Eli Yablonovitch
REGENTS OF THE UNIVERSITY OF CALIFORNIA THE

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Final Report

Air Force Research Laboratory
AF Office Of Scientific Research (AFOSR)/ RTB1
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Air Force Materiel Command

REPORT DOCUMENTATION PAGE

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6. AUTHOR(S)
Eli Yablonovitch
Ming Wu

5d. PROJECT NUMBER

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5f. WORK UNIT NUMBER

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Berkeley, CA 94704-5940

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14. ABSTRACT
The goal of this project was to show that spontaneous emission could be accelerated by an optical antenna, to the point that it would become faster than stimulated emission. This would require spontaneous emission acceleration by 200x. The project has succeeded, both for optically pumped spontaneous emission, and electrically pumped spontaneous emission. We have observed a speedup of >300x, and we project a speedup of 2500x at an optimal antenna gap spacing, ~10nm. We intend to present a publicity release based on this accomplishment. Actually, a narrower antenna gap would result in further speedup, but at progressively lower efficiency. The reason for this is that an oscillating atomic dipole induces optical frequency currents in the adjacent parts of the metal antenna. These currents are subject to Ohmic losses, cutting the antenna efficiency. Thus we have been encouraging our competitors to place a secondary requirement on spontaneous emission acceleration. It should be accompanied by antenna efficiency of >50%.

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Nanophotonic Devices; Spontaneous Emission Faster than Stimulated Emission
FA9550-15-1-0024

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We believe that these new types of spontaneous emission optical sources, acting as antenna enhanced Light Emitting Diodes, can enable short distance optical communication, including possibly on-chip optical interconnect. One of the motivations for this is the LED's, unlike lasers, require no threshold current, and could be much more energy efficient. Another motivation is that the antenna LED can be perhaps 10 times faster than the laser. We are continuing to investigate other aspects of the antenna-LED communications link, from the viewpoint of the optical detector requirements, with the aim of enabling a complete optical communications channel at the nano-scale.

Publications during past year:

1. M.S Eggleston, K. Messer, L. L. Zhang, E. Yablonovitch, M.C. Wu, "Optical Antenna Enhanced Spontaneous Emission", Proc. Nat. Acad. Sci. 112, 1704-1709 (2015). dx.doi.org/10.1073/pnas.1423294112
2. M. S. Eggleston and M. C. Wu, "Efficient Coupling of an Antenna-Enhanced nanoLED into an Integrated InP Waveguide," Nano Letters, vol. 15, no. 5, pp. 3329--3333, May 2015.

Patents during past year:

1. "Nano-Fabricated Plasmonic Optical Transformer", (with H. Choo, S. Cabrini, P.J. Schuck, X. Liang,) U.S. Patent No. 9,052,450 (Jun. 9, 2015).
2. "Probes for Multi-Dimensional Spectroscopic Imaging, and Methods of Fabrication Thereof", (with A. Weber-Bargioni, S. Cabrini, W. Bao, M. Melli, and P.J. Schuck) U.S. Patent No. 8,984,661 (Mar. 17, 2015).

Invited Presentations during Past Year:

1. Oliver Buckley Condensed Matter Physics Prize, 2015, American Physical Society, for "seminal achievements in solar cells, strained lasers, & photonic crystals."
2. Present Invited Papers at AVS and OSA Conferences, San Jose, CA, October 2015
3. Royal Swedish Academy at the Light in the Service of Mankind conference, Lund, Sweden, October 2015

4. Present Invited Paper at Beyond CMOS Conference, sponsored by IMEC, Leuven, Belgium, October 2015
5. Present Invited Paper at San Diego META Conference, July 2015
6. Present Invited Paper at International Nanotechnology Conference on Communication and Cooperation, Fukukoka, Japan, May 2015
7. Present Plenary Address at CMOS Emerging Technologies Research Conference, Vancouver BC, May 2015
8. Present Invited Paper at TOTAL solar conference, Santa Clara, CA, February 2015
9. Present Invited Paper at ITRS roadmap meeting, Palo Alto, CA, February 2015

Awards Past Year:

1. Isaac Newton Medal & Prize, 2015, the highest award of the UK Institute of Physics, for "his visionary and foundational contributions to photonic nanostructures."

AFOSR Deliverables Submission Survey

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1.

1. Report Type

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The Regents of the University of California

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Nanophotonic Devices; Spontaneous Emission Faster than Stimulated Emission

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FA9550-15-1-0024

Principal Investigator Name
The full name of the principal investigator on the grant or contract.

Eli Yablonovitch; Ming Wu

Program Manager
The AFOSR Program Manager currently assigned to the award

Harold Weinstock

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10/31/2015

Abstract

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Archival Publications (published) during reporting period:

1. M.S Eggleston, K. Messer, L. L. Zhang, E. Yablonovitch, M.C. Wu, "Optical Antenna Enhanced Spontaneous Emission", Proc. Nat. Acad. Sci. 112, 1704-1709 (2015). dx.doi.org/10.1073/pnas.1423294112
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Changes in research objectives (if any):

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Extensions granted or milestones slipped, if any:

None

AFOSR LRIR Number

LRIR Title

Reporting Period

Laboratory Task Manager

Program Officer

Research Objectives

Technical Summary

Funding Summary by Cost Category (by FY, $K)

	Starting FY	FY+1	FY+2
Salary			
Equipment/Facilities			
Supplies			
Total			

Report Document

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Appendix Documents

2. Thank You

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